Information-analytical support of project management processes with the use of simulation modeling methods

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Abstract
The prerequisites for the creation and use of information and analytical systems to support decision-making in crop harvesting projects are revealed. Peculiarities of the project environment influence on the winter rape harvesting projects implementation are given. The development and results of the information-analytical system using for project management processes support are presented. The method of taking into account the impact of the project environment (subject and agrometeorological conditions) on the timing and work timeliness in harvesting projects is presented. The expediency of simulation models creating and the method of the probabilistic conditions reflecting of the technical equipment of agricultural crops harvesting projects are described. The results of computer experiments to assess the impact of the start time of projects and the area of culture on the volume of harvested and lost crops are presented.

Keywords
Information-analytical systems, project environment, risk, simulation, project management, Efficiency.

1. Introduction

The tasks of projects management of the agro-industrial complex (AIC) development in Ukraine are promising for various reasons. Their implementation makes it possible to guarantee the food security of the state, filling the budget, meeting the demand for agricultural products from foreign markets, and so on. It should also be noted that the management of these projects is characterized by risk due to the impact of the project environment in most sectors of AIC. This affects the uncertainty during the projects implementation and creates requirements for the creation and use of information and analytical systems to management decisions support.

It is well known that the work timeliness in crop harvesting projects affects the volume of production and affects their efficiency in general. To ensure this timeliness, it is necessary to adhere to multi-term work plans and, in particular, to operate with a significant amount of resources and information. However, due to the negative manifestation of the agrometeorological component of the project environment, work may be delayed, which will lead to technological losses [1]. To take into account these features of AIC projects, it is necessary to develop and apply information-analytical systems for risk assessment, which will allow to form recommendations for improving the management of these projects [2, 3].

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2. Analysis of published data and problem setting

Analysis of recent research and publications convinces that for the planning and implementation of agricultural production projects were using the statistical methods and simulation models [4] to justify the parameters of their technical equipment (complexes of agricultural machinery) [5-9]. However, the current methods do not allow to take into account the variability of the project environment, in particular, the subject and agrometeorological components [10, 11]. Their impact is characterized by stochasticity and affects the work timeliness in projects [8]. The usage of known methods and models for planning projects of technological systems [12, 13], unfortunately, does not allow to objectively take into account the impact of the external environment, and thus establish the value of these projects and ensure proper management.

The aim of the research to present the methods of information-analytical support of project management processes, as well as the results of simulation of the work timeliness in agricultural harvesting projects.

3. Results of research

The creation of information-analytical systems to support decisions in crop management projects should be carried out in the context of displaying and forecasting time constraints on the works implementation in these projects [2, 3]. In particular, for winter rapeseed harvesting projects, this can be achieved through the development of statistical simulation models [4, 14-17], which are aimed at the reproduction of subject-biological phenomena and processes (Figure 1) [11]: 1) accumulation of effective air temperatures; 2) the rate of pods drying and plant seeds ripening; 3) the impact of agrometeorological conditions on the physical condition of the fields ground (subject of work) and the work possibility of technical equipment, etc. [18].

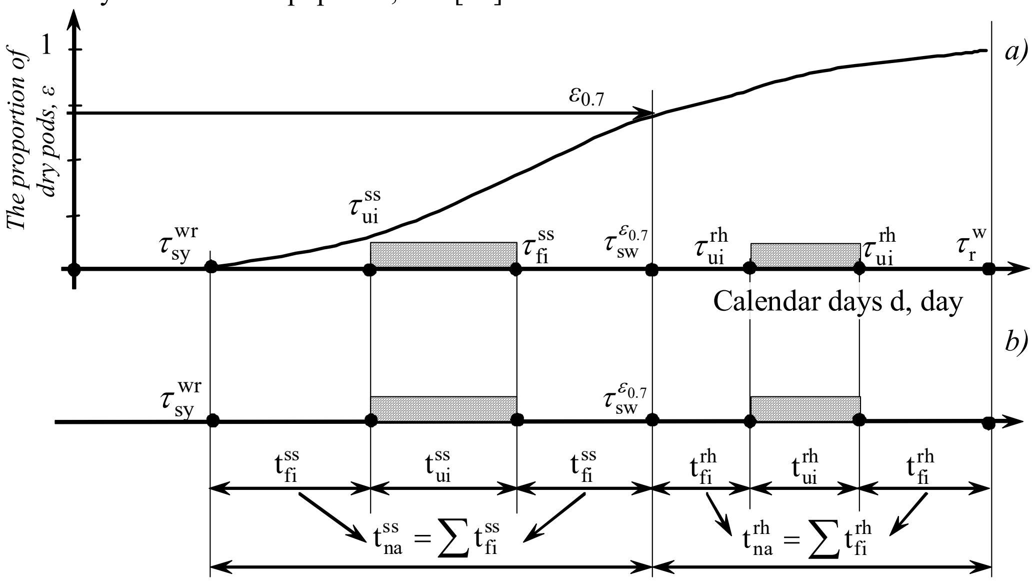

Figure 1: Reflection of the impact of the natural component of the project environment on the time fund for work in winter rapeseed harvesting projects: a) calendar change in the state of the harvest; b) naturally allowed time for work; t_{fi}^{ss}, t_{ui}^{ss}, t_{fi}^{rh}, t_{ui}^{rh} – respectively, the duration of favorable and unfavorable intervals; t_{na}^{ss}, t_{na}^{rh} – accordingly, the duration of the naturally allowed time to perform the work

One of the defining features of winter rapeseed harvesting projects, which shape the timing and pace of work in the projects, is that the processes of reaching the pods and seeds of the plant are uneven and long-lasting. The unevenness of their maturation leads to cracking of the pods and self-scattering of seeds, which can reach 90-100% of losses [11]. To "leveling" the ripeness of seeds, get more oil, reduce technological losses, and increase the harvest enterprises use the technology of direct combining with pre-harvest spraying of stems with gluing pods [19].

According to the recommendations of practitioners, winter rapeseed can be harvested from the moment 70% of dry ($\varepsilon_{0.7}$) pods appear in the field. However, under such conditions, a certain amount of crop yield is lost, which can be obtained by increasing the mass of seeds between the beginning and end of work on projects [10]. The expediency of using the indicator of the share of dry pods ε to decide on the start of work (τ_{sw}^{ε}) is that in practice in the field it is easier and faster to assess the ripeness of the winter rapeseed crop by the quality of the pods. It does not require additional time and equipment to establish the average humidity and weight of the seeds.

We have created a statistical simulation model of projects work, which takes into account the described impact of the project environment. Its application makes it possible to implement information-analytical support of decision-making in projects through the computer experiments [20]. Elaboration of the experiments results makes it possible to assess of work timeliness in projects at different times of their execution.

The applying of mathematical statistics methods to process the modeling results made it possible to establish estimates of the mathematical expectations of the following indicators: 1) the gross volume of the harvest; 2) gross volume of lost yield; 3) specific volumes of harvest.

It should be noted that the simulation modeling of projects works was performed for a given variant of technical equipment – Mekosan Tecnoma Laser 4240-30 and CLAAS Mega 360, which operates in agro-meteorological conditions of Yavoriv district of Lviv region during harvesting of winter rapeseed "Antaria". Statistical simulation was performed for the set limits of the production area (S_r) of the crop – 10-600 ha with a stepwise increase of 10 ha. This made it possible to establish patterns of change in the main functional indicators of the effectiveness of work in projects.

In particular, the obtained results (Figure 2, Table 1) show that the start of work in winter rape harvest projects from the moment of 70% of dry pods ($\varepsilon_{0.7}$) in the field increases the probability of larger harvests and lower losses [1]. This means that the work in the projects will be carried out in accordance with the harvest. Then, the simple ripe harvest on the field will be minimal.

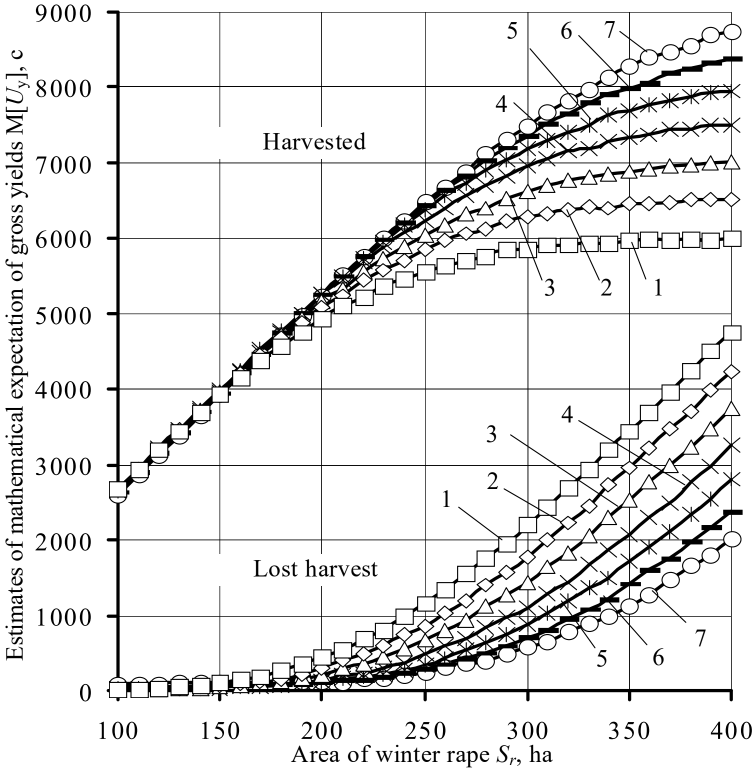

Figure 2: Dependence of mathematical expectation estimates of harvested and lost yields on the area of winter oilseed rape at different planned conditions of the works beginning in projects: 1 – $\tau_{sw}^{\varepsilon_{1.0}}$; 2 – $\tau_{sw}^{\varepsilon_{0.95}}$; 3 – $\tau_{sw}^{\varepsilon_{0.9}}$; 4 – $\tau_{sw}^{\varepsilon_{0.85}}$; 5 – $\tau_{sw}^{\varepsilon_{0.8}}$; 6 – $\tau_{sw}^{\varepsilon_{0.75}}$; 7 – $\tau_{sw}^{\varepsilon_{0.7}}$

Table 1
Equations and correlations dependence of mathematical expectation estimates of lost yields on the area of winter oilseed rape at different planned conditions of the works beginning in projects

Planned conditions of works beginning τ_{sw}^{ε}	Dependence of estimates	Correlation ratio
$\tau_{sw}^{\varepsilon 0.7}$ (70% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.7}\right] = 1\cdot10^{-4}\cdot S_r^3 - 0.0388\cdot S_r^2 + 4.9723\cdot S_r - 109.08$	0,992
$\tau_{sw}^{\varepsilon 0.75}$ (75% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.75}\right] = 9.2\cdot10^{-5}\cdot S_r^3 - 0.0269\cdot S_r^2 + 2.0491\cdot S_r + 47.814$	0,991
$\tau_{sw}^{\varepsilon 0.8}$ (80% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.8}\right] = 7.8\cdot10^{-5}\cdot S_r^3 - 0.0099\cdot S_r^2 - 1.9389\cdot S_r + 284.55$	0,992
$\tau_{sw}^{\varepsilon 0.85}$ (85% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.85}\right] = 5\cdot10^{-4}\cdot S_r^3 + 0.0138\cdot S_r^2 - 6.8683\cdot S_r + 560.48$	0,992
$\tau_{sw}^{\varepsilon 0.9}$ (90% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.9}\right] = 7\cdot10^{-6}\cdot S_r^3 + 0.0497\cdot S_r^2 - 13.828\cdot S_r + 952.49$	0,993
$\tau_{sw}^{\varepsilon 0.95}$ (95% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 0.95}\right] = 3.9\cdot10^{-5}\cdot S_r^3 + 0.0856\cdot S_r^2 - 20.787\cdot S_r + 1344.5$	0,992
$\tau_{sw}^{\varepsilon 1.0}$ (100% ripe stems)	$\overline{M}\left[U_y^{\varepsilon 1.0}\right] = -8.2\cdot10^{-5}\cdot S_r^3 + 0.118\cdot S_r^2 - 25.781\cdot S_r + 1558.4$	0,991

Thus, information and analytical support of project management processes, as well as coordination of work (time and content of projects), resources and management decisions with the laws of the project environment allows to find their "ratio" at which the manifestation of technological risk will be insignificant and achieve maximum efficiency of projects.

4. Conclusions and prospects of further researches

Tasks for managing crop harvesting projects are due to the need to increase their value by taking into account the stochastic impact of the project environment (in particular, subject and agrometeorological components). The methods and models development that take into account these features will create an information-analytical system to support decision-making during the realization of these projects. Performing computer experiments with these models allows you to quantify the performance of projects, and after that substantiate management decisions to implement relevant processes in practice. The obtained simulation results show that the start of harvesting (τ_{sw}^{ε}) projects since the appearance of 70% ($\varepsilon_{0.7}$) of winter rape dry pods allows to provide relatively larger volumes of harvested crops and lower technological losses (Figure 2). In this case, the rational use of the unit area of the enterprise will be provided, relatively higher load of projects technical support, smaller volumes of winter rape unharvested areas and larger gross volume of harvested crops. The established dependences of the amount of technological losses on the area of winter oilseed rape are described by a polynomial of the third degree (Table 1). Their use makes it possible to evaluate the effectiveness of information and analytical support of harvesting projects.

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